



## TOWN LAKE FISH TISSUE STUDIES

By Martha A. Turner, P.E.

City of Austin  
Watershed Protection Department  
Environmental Resources Management Division

Originally published 2001  
Revised April 2003

### ABSTRACT

*Fish from Town Lake, Austin, Texas have historically had elevated levels of several probable human carcinogens in their tissue. Consumption advisories and/or consumption bans were in effect from 1987 to 1999 for Town Lake fish. Seven sets of fish tissue data from 1981 to 1998 were investigated visually for trends, and compared with U.S. Environmental Protection agency (EPA) and U.S. Food and Drug Administration (FDA) criteria. Concentrations were normalized by weight. Concentrations, normalized median concentrations, and normalized median concentrations for four feeding groups (piscivore, invertivore, omnivore, and herbivore) were examined for chlordane, total DDT, PCB, copper, mercury and zinc. In general, toxic constituents peaked in the first year they were measured followed by a substantial drop at the succeeding measurement. Recent changes are quite gradual or non-existent. Overall, current levels of tissue concentrations do not pose a threat to human health (based on 1998 criteria) although individual fish can still be found above the FDA action levels for some pollutants. However, based on the 2001 US EPA reference dose for mercury, which has not yet been adopted by the State of Texas, fish consumption limits may need to be reinstated. Additional sampling and data analysis may be needed if Texas adopts the 2001 US EPA criteria.*

### INTRODUCTION

Fish from Town Lake historically have had elevated levels of several probable human carcinogens in their tissue. Consumption advisories and/or consumption bans were in effect from 1987 to 1999 for Town Lake fish. The consumption ban was lifted on October 26, 1999, following analysis of the 1998 sample data.

Resident fish in a reservoir acquire toxins through bioaccumulation and biomagnification. High concentrations of metals, PCBs, and organochlorine pesticides in Town Lake sediment are a potential source for the high levels in fish tissue. Detailed descriptions of the studies on Town Lake fish and sediment are described in the Town Lake Study Vol. I (COA, 1992) and in the Draft Town Lake Update Report (2003). The results of these fish tissue studies are summarized in this short paper.

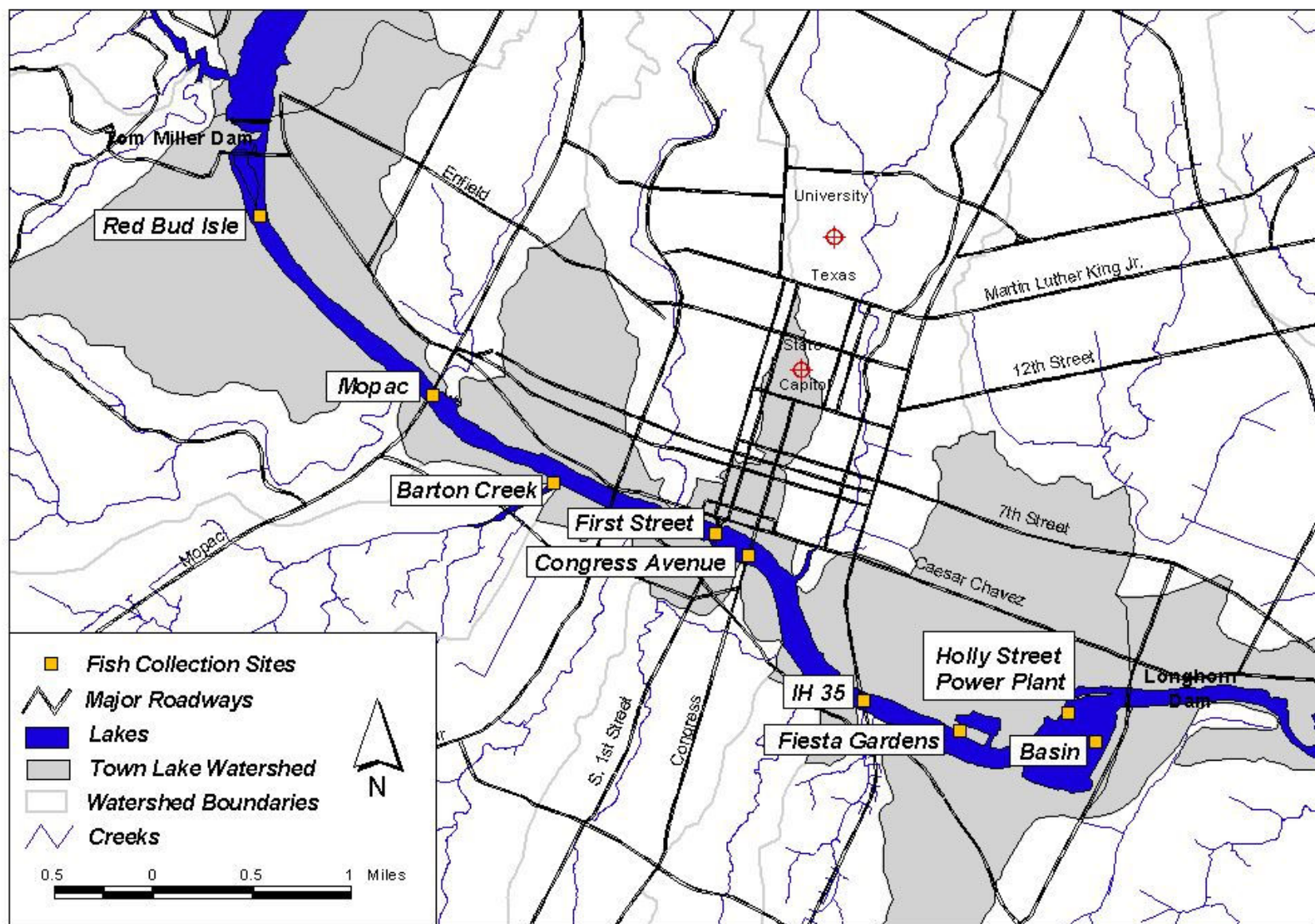
Fish were collected seven times from Town Lake between 1981 and 1998 by five different agencies at different locations. As with all multi-year, multi-agency studies, the locations, fish varieties, fish size, labs, analysis methods and measured parameters differed with each collection. These variations cause some difficulty with comparisons and interpretation, since the sampled population distribution may differ from the actual population distribution and the uptake of sediment contamination by under-represented bottom feeding species differs from the rest of the population.

Twenty-one types of fish from four feeding groups were caught (Table 1). The feeding groups were piscivores (fish that eat other fish), omnivores (fish that eat most anything), invertivores (fish that feed primarily on benthic

macroinvertebrates), and herbivores (fish that eat mostly plankton). Fish were collected at 9 locations in Town Lake (Figure 1 and Table 2). During one sample collection, the specific location within the lake was not recorded.

Figure 2 shows the number in each fish-feeding group for each year and site group. The inconsistent nature of the sampling both in terms of sites and fish types make analysis of the data difficult. Specifically, it prevents the assessment of location differences, the estimation of time trends for some species, and reduces the representativeness of the total Town Lake biomass distribution. For example, in 1998 herbivores and invertivores, which comprise a majority of the fish population, were not sampled.

Figure 1 Map of Fish Collection Sites in Town Lake, Austin, Texas.



**Table 1**  
**Number of Fish Collected from Town Lake for Tissue Analysis and their Feeding Groups**

Number of fish collected	1981	1985	1987	1990	1994	1995	1998	Total	Feeding Group
largemouth bass	1		6	17	23	8	4	59	Piscivore
smallmouth bass				2				2	Piscivore
white bass		1				2		3	Piscivore
striped bass		2				1		3	Piscivore
black bass		14						14	Piscivore
flathead catfish				8		7	2	17	Piscivore
channel catfish		2	3	7		2	1	15	Omnivore
blue catfish			3			1	1	5	Omnivore
yellow bullhead			1					1	Omnivore
common carp		11	2	19	6	3		41	Omnivore
smallmouth buffalo				1		1	2	4	Omnivore
redhorse sucker			6	5	14	5		30	Omnivore
freshwater drum						3	2	5	Omnivore
gizzard shad		13	6	11	6	2		38	Herbivore
rio grande perch	2	3						5	Invertivore
redbreasted sunfish	3			2	1			6	Invertivore
bluegill sunfish	2							2	Invertivore
redeer sunfish	2	5			2			9	Invertivore
yellow belly sunfish		4						4	Invertivore
warmouth sunfish		2						2	Invertivore
long eared sunfish		1						1	Invertivore
<b>Total</b>	<b>10</b>	<b>58</b>	<b>27</b>	<b>72</b>	<b>52</b>	<b>35</b>	<b>12</b>	<b>266</b>	

**Table 2**  
**Collection Sites**

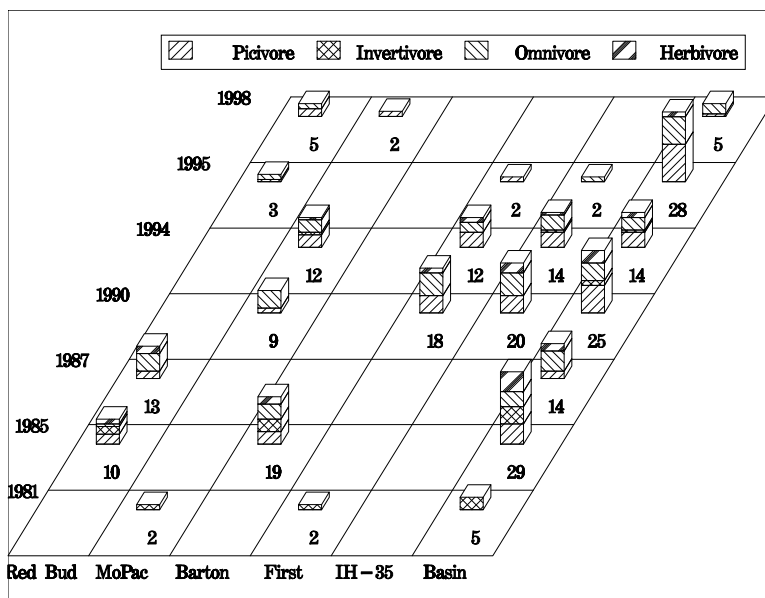
SITE	Number of samples collected
Town Lake (specific location in lake unknown)	1
Town Lake @ Red Bud Isle (EC)	31
Town Lake @ MoPac Bridge	25
Town Lake @ Barton Creek (FC)	19
Town Lake @ 1st St (CC)	2
Town Lake @ Congress Avenue Bridge	32
Town Lake @ IH35 (BC)	36
Town Lake @ Fiesta Gardens	3
Town Lake @ Holly Street Power Plant	19
Town Lake @ Basin (AC)	98

## METHODS

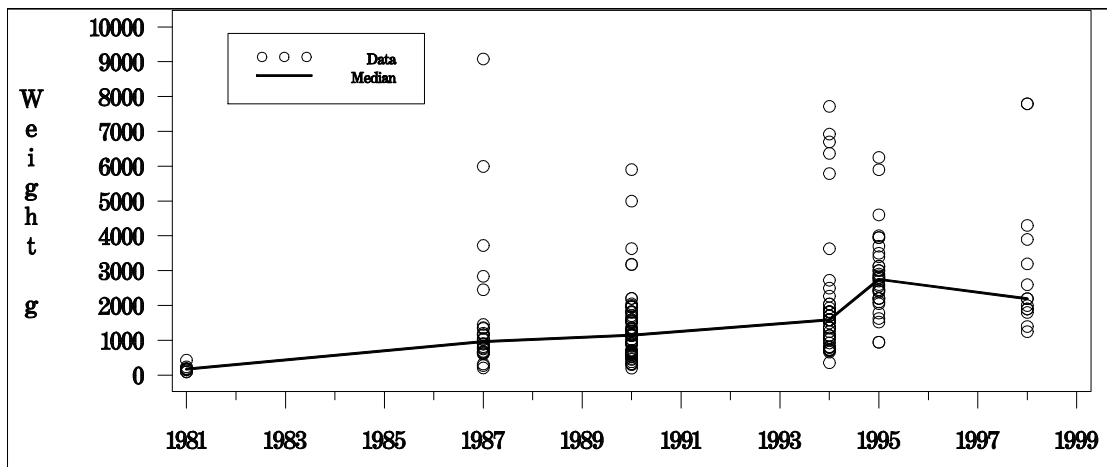
### Fish Size - Normalization

The size of the fish that were caught has been increasing over time, except in 1998. The median fish size was smaller in 1998 than in 1995, although the 1998 median weight was larger than in 1994. Figure 2 shows the change in weight of the fish over time. Larger fish tend to be older and have had more time to accumulate toxins. In order to compare fish tissue concentrations from different years, the entire data set was normalized by dividing the concentration of each fish by its weight.

**Figure 2**  
**Fish Feeding Groups**



**Figure 3**  
**Sampled Fish Weights over Time**



## **Parameters**

Only metals, organochlorine compounds, and PCBs have been consistently measured in the tissue of Town Lake fish. Other sporadically measured data are available for other organics, herbicides, and pesticides. In the metals group only copper, mercury and zinc have sufficient data above the detection limits for determining trends visually. The organochlorine compounds with adequate data above detection to evaluate trends visually include chlordane, DDT, DDE, and DDD.

## **Analysis**

The concentrations (not normalized) for all sites and fish groups for each year for chlordane, the sum of DDT, DDD, and DDE, PCBs, copper, mercury and zinc are displayed in Figure 4. In order to compare between years, the normalized concentration medians were calculated. Figure 5 shows the change in the normalized median concentrations of these parameters over time. All of the parameters, except mercury, have their highest concentration in the first year they were measured followed by a substantial drop at the succeeding measurement. After the sharp drop, the decline is more gradual or even essentially level. However, the averaged concentrations of chlordane, the sum of DDT, DDD, and DDE, and PCBs were still high enough to require a fish consumption advisory until 1998. Mercury displays a different pattern than the other parameters and peaks in the middle of the time period rather than at the beginning.

## **RESULTS**

### **1998 Study Results**

PCBs, volatile and semi-volatile organic compounds other than pesticides were not detected in the 1998 samples. Pesticides were detected in all the fish. However, the concentrations of chlordane were lower than in 1995 and were detected in a lower percentage of the fish. Additionally, the chlordane isomers observed in the samples showed some evidence of degradation. The data from this study indicated that a person eating Town Lake fish would be exposed to several probable human carcinogens simultaneously. These chemicals, Chlordane, DDT, DDE, and DDD, primarily affect the liver. The cumulative lifetime carcinogenic risk for these chemicals was estimated to be  $2.35 \times 10^{-5}$ . This risk level is more than four times smaller than the risk estimated in 1995. The decrease in risk is due to both decreases in concentrations and revision, by USEPA, of the numerical factors used in calculating risk for chlordane. The TDH also calculated the non-carcinogenic health risk from fish consumption and found the Hazard Index to be acceptable. The overall conclusion of the assessment was that the consumption of fish from Town Lake poses no apparent health hazard. The Texas Department of Health lifted the Fish Consumption Advisory on October 26, 1999.

Small quantities of metals were found in several fish but the levels did not pose a threat to human health using the 1998 EPA reference doses. A new reference dose for mercury was announced by EPA in January of 2001. Using this new reference dose would require a monthly consumption limit from Town Lake fish. However, state criteria have not been revised as of September 2003.

### **Feeding Groups**

The fish were split into feeding groups in order to examine the effect of diet on changes in tissue concentrations over time. The four fish feeding groups are the piscivores, omnivores, benthic invertivores, and herbivores. Figure 6 shows the normalized median fish tissue concentrations for each of the four groups over time. The fish that eat benthic macroinvertebrates usually had the highest median concentrations of pesticides, PCBs and metals in their tissue. The next highest concentrations were typically found in the herbivores. Piscivores and omnivores displayed the lowest normalized concentrations. For metals, the median concentrations were slightly higher in the piscivores, and for pesticides and PCBs the concentrations were about the same in the omnivores and piscivores. The ranking of the four feeding groups is the same as for non-normalized data. The only herbivores sampled were gizzard shad.

They are oily fish and frequently feed on the bottom. These two factors may lead to their high concentrations because of higher contaminant solubility in oily tissue and higher availability of metals in bottom sediment than in the water column.

### **Location**

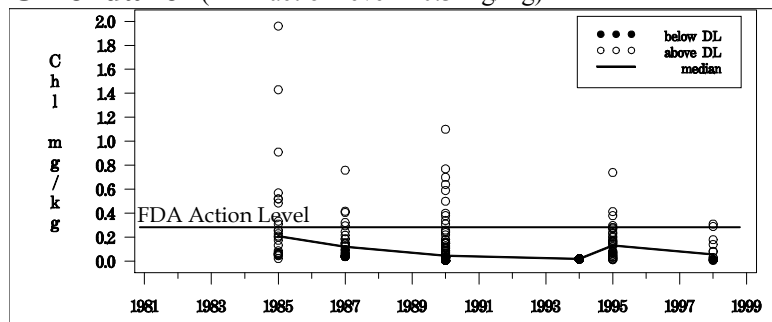
Samples were not taken at the same sites each year. Since concentrations and types of fish obtained at each site were changing over time, the comparison of site concentrations is inappropriate.

### **Chlordane**

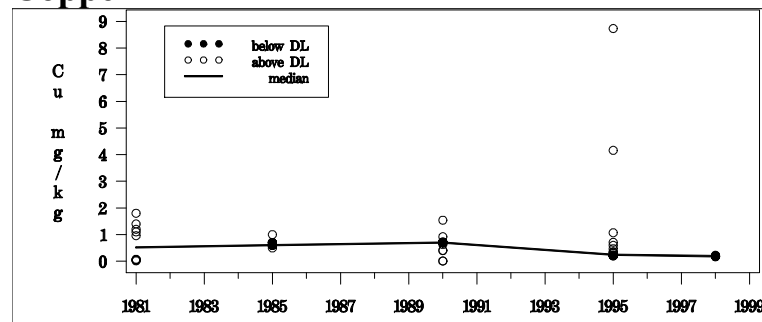
Fifty-five percent of the 222 fish tissue concentrations were above the detection limits for chlordane. These concentrations ranged from 0.0128 to 1.96 mg/Kg over all labs and the period of record. The highest levels were observed in 1985 at the Basin. The majority of the chlordane concentrations were above the detection limit except in 1994 when they were all below detection. The maximum detected chlordane concentrations in Town Lake fish have been declining, although 1 of the 12 fish sampled in 1998 (8%) still had a concentration above the FDA action level of 0.3 mg/Kg. Chlordane levels in Town Lake sediment, a potential source for the fish tissue levels, have declined significantly over time.

**Figure 4 Fish Tissue Concentrations in Town Lake**

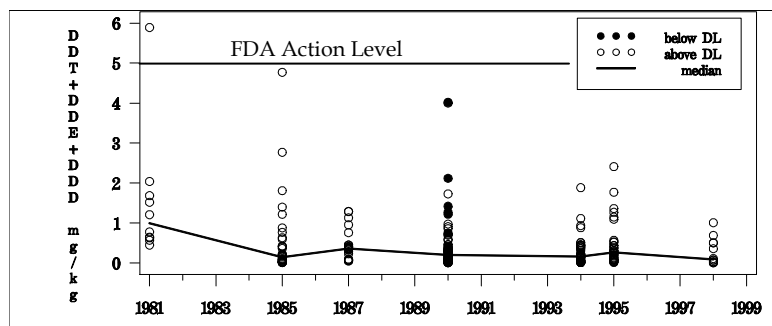
**Chlordane** (FDA action level = 0.3 mg/Kg)



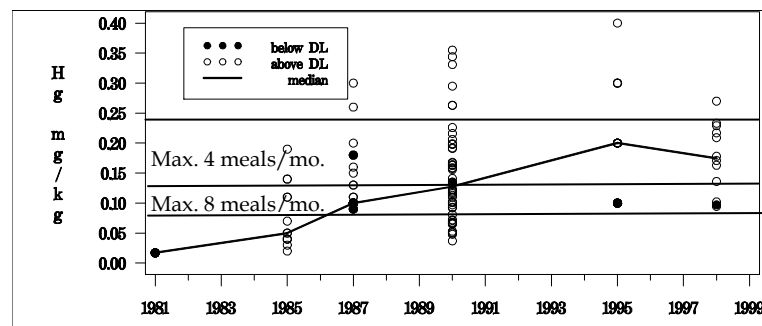
**Copper**



**DDT + DDE + DDD** (FDA action level = 5 mg/Kg)



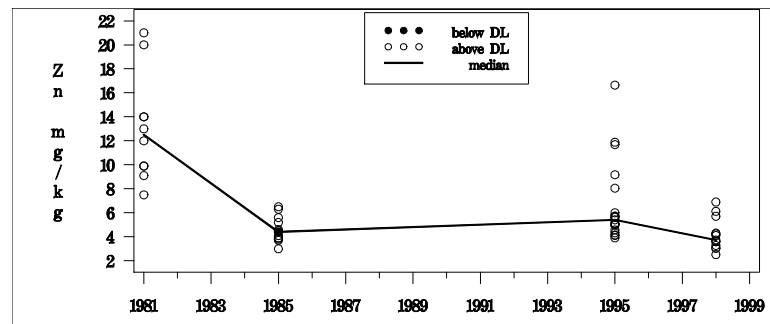
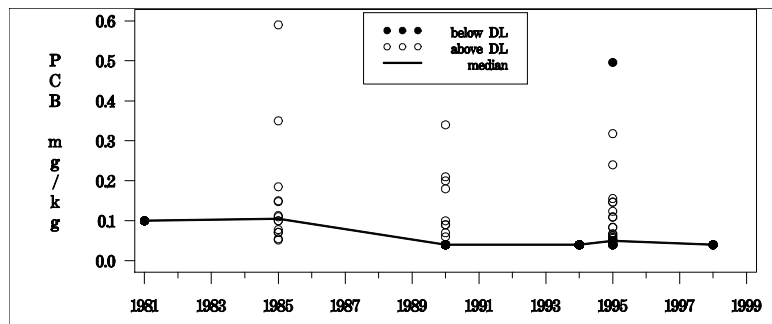
**Mercury** (EPA fish consumption recommendations in Table 3)



**PCBs**

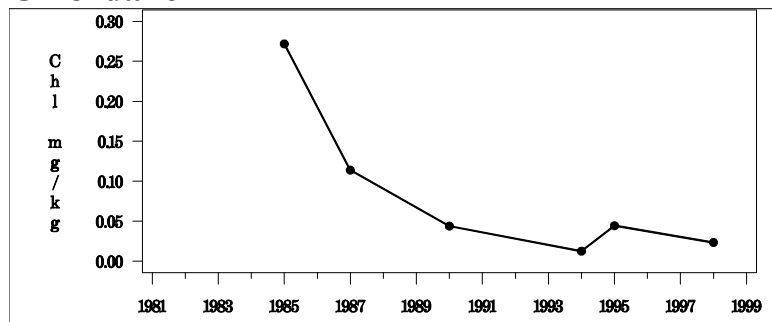
**Zinc**



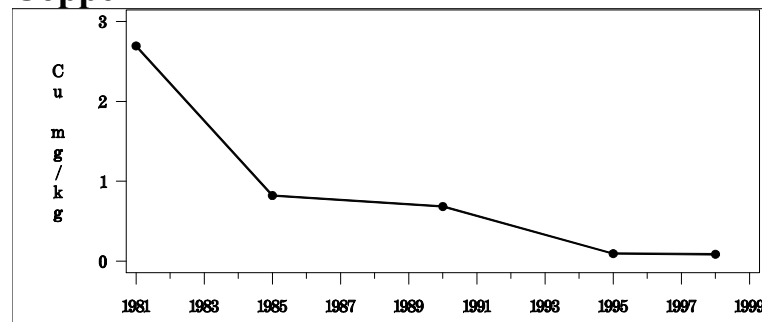


**Figure 5 Normalized Median Concentrations in Town Lake**

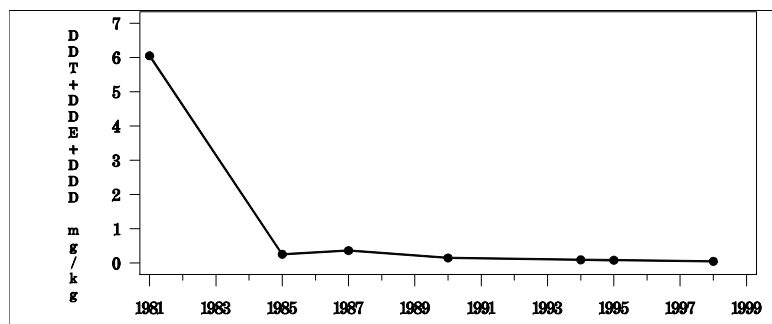
**Chlordane**



**Copper**



**DDT + DDE + DDD**



**Mercury**



**PCBs**

**Zinc**

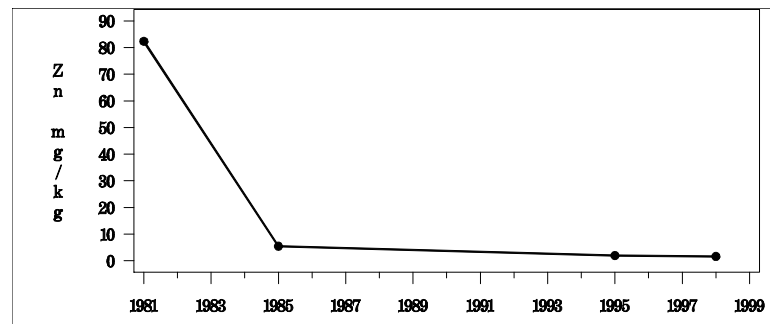
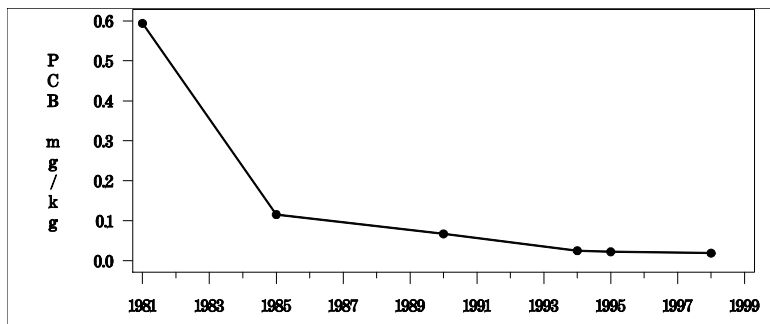
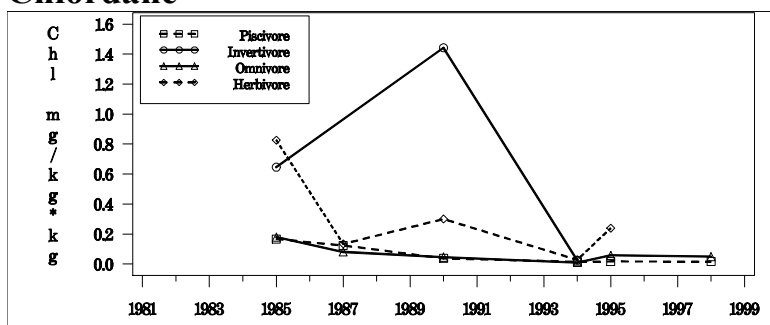
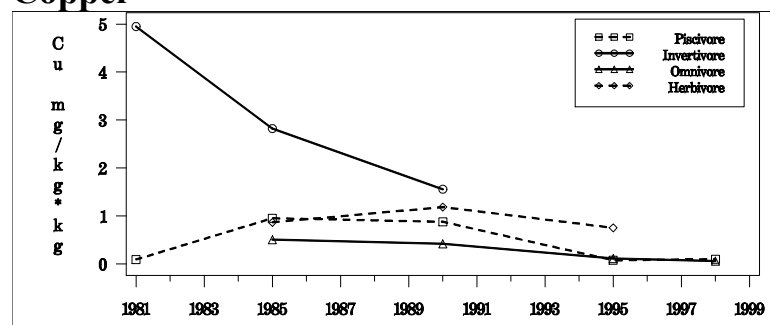


Figure 6 Normalized Median Concentrations by Feeding Group in Town Lake Fish

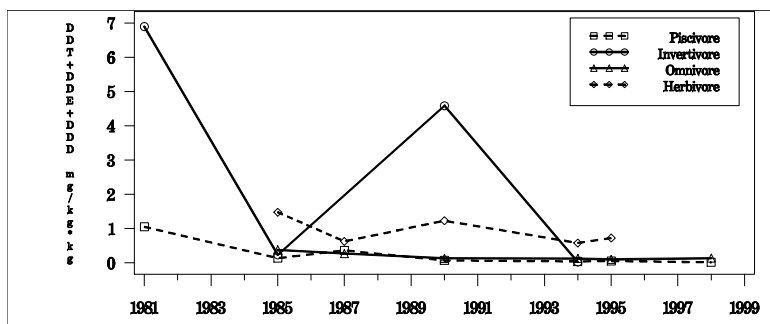
### Chlordane



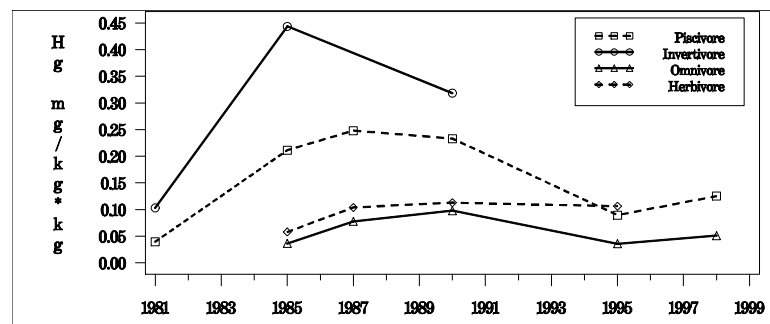
### Copper



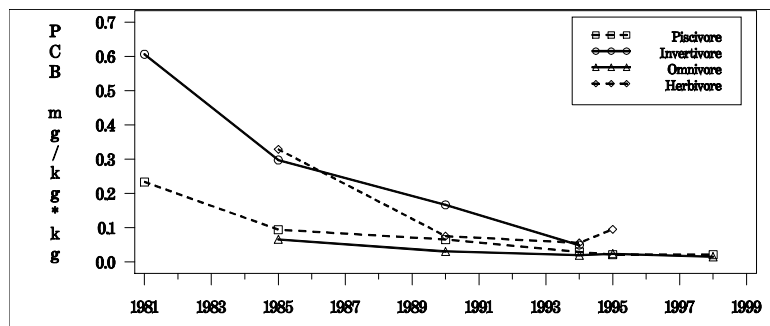
### DDT + DDE + DDD



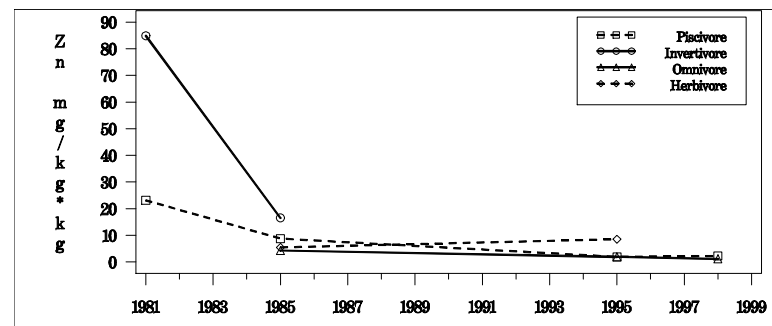
### Mercury



## PCBs



## Zinc



## **Total DDTs**

Total DDT is the sum of the concentrations for DDT, DDE and DDD. Eighty-four percent of the 243 fish tissue concentrations were above the detection limits. These concentrations ranged from 0.005 to 5.89 mg/Kg. The highest levels were observed in 1981 at the Basin. Before 1990 almost all of the fish tissue concentrations of DDT and its derivatives were above the detection limits. From 1990-on, quite a few concentrations were below the detection limits although the detection limits were higher than in the past in some cases. The maximum detected total DDTs concentration in Town Lake fish have been declining and are all below the FDA action level of 5 mg/Kg in recent years. The predominant form of total DDTs in recent samples is DDE, an extremely persistent breakdown product of DDT. Total DDT levels in Town Lake sediment, a potential source for the fish tissue levels, have declined significantly over time.

## **PCB**

PCB levels above the detection limits were found in Town Lake fish in 1985, 1990 and 1995. Note that the detection limits do vary significantly and indeed in 1995, the highest detection limit was greater than any detected concentration. Twenty-five percent of the 155 fish tissue samples had concentrations of PCBs above the detection limits. These concentrations ranged from 0.049 to 0.59 mg/Kg. The highest level was observed in 1985 at the Basin. The maximum observed concentrations have decreased over time.

## **Metals**

Only three metals, mercury, zinc and copper, had sufficient data above the detection limits for long term analysis. Trends over time for these three are examined below. Five other metals (lead, chromium, arsenic, selenium and cadmium) had concentrations that were mostly below detection limits or were sampled infrequently.

## **Mercury**

Seventy-seven percent of the 133 fish tissue concentrations were above the detection limits. These concentrations ranged from 0.02 to 0.4 mg/Kg. The highest level was observed in 1995 at the Basin. Mercury does not follow the pattern of most of the rest of the parameters. Maximum mercury concentrations have been steadily increasing rather than decreasing. However when the concentrations are normalized by fish weight, levels peak in the middle of the time period. All the fish feeding groups display this pattern.

In January 2001, the US EPA announced a new reference dose for methylmercury of  $1 \times 10^{-4}$  mg/kg-d and recommended that all mercury in fish should be assumed to be present as methylmercury. Table 3 shows the recommended monthly fish consumption limits for methylmercury in fish based on EPA's default values for risk assessment parameters for the fish sampled from Town Lake in 1998. Twelve fish were analyzed for mercury and only one had mercury levels below a detection limit of 0.097 mg/kg. Consumption limits have been calculated as the number of allowable 8 oz. fish meals per month for a 72 kg (159 lb) adult based on the ranges of methylmercury in the consumed fish tissue. The State of Texas has not changed its criteria to match the federal one.

**Table 3. Monthly Fish Consumption Limits for Methylmercury**

<b>1998 Town Lake Fish</b>	<b>Risk-based consumption limit</b>	<b>Noncancer health endpoints</b>
<b>Percent in category</b>	<b>8 oz. fish meals/month</b>	<b>Fish tissue concentrations (ppm or mg/kg, wet weight)</b>
17%	8	> 0.08–0.12
67%	4	> 0.12–0.24
8%	3	> 0.24–0.32

## **Zinc**

Zinc tissue levels were determined in 1981, 1985, 1995 and 1998. All but one of the 55 fish tissue samples had concentrations that were above the detection limits. These concentrations ranged from 2.5 to 21.0 mg/Kg. The highest concentration was observed in 1981 at MoPac. Maximum concentrations decreased in 1985, increased in 1995, and then decreased again in 1998. However, when the concentrations were normalized, the typical pattern of decreasing maximum and median concentrations becomes apparent. The change from 1985 to 1998 is minimal, implying that normalized zinc concentrations may be stable in Town Lake fish.

## **Copper**

Forty-one percent of the 107 fish tissue samples had concentrations that were above the detection limits. These concentrations ranged from 0.01 to 8.7 mg/Kg. The highest levels were observed in 1995 at the Basin. However the normalized concentrations were highest in 1981, remained approximately the same from 1985 to 1995 and then decreased in 1998.

## **Lead**

Only fifteen percent of the 121 fish tissue concentrations were above the detection limits. These concentrations ranged from 0.10 to 2.2 mg/Kg. The highest levels were observed in 1990 at First Street.

## **Chromium**

Only thirty-two percent of the 66 fish tissue concentrations were above the detection limits. These concentrations ranged from 0.22 to 1.0 mg/Kg. The highest level was observed in 1987 at Red Bud.

## **Arsenic**

Only sixteen percent of the 69 fish tissue concentrations were above the detection limits. These concentrations ranged from 0.025 to 0.340 mg/Kg. The highest levels were observed in 1987 at Red Bud.

## **Selenium**

Selenium tissue levels were determined in only two years, 1990 and 1998. Sixty-three percent of the 32 fish tissue concentrations were above the detection limits. These concentrations ranged from 0.13 to 0.49 mg/Kg. The levels were lower in 1998 than in 1990. The highest level was observed in 1990 at First Street.

## **Cadmium**

Cadmium tissue levels were above the detection limit in only two samples, one taken in 1981 and one in 1998. Thirty percent of the 56 fish tissue concentrations were above the detection limits. These concentrations ranged from 0.0005 to 0.021 mg/Kg. The levels were similar in 1981 and 1998. The highest level was observed at Red Bud in 1998.

## **CONCLUSIONS**

- Although a large amount of fish tissue data exists for Town Lake, sporadic sampling, variable collection and analytical methods, changes in sample location, and variable species composition, make data analysis difficult and reduce confidence with respect to representativeness of total fish biomass in the lake.
- Normalization by individual weight is necessary before comparisons between years can be done, because of the increasing weight/age trend in the fish samples.
- In general toxic constituents are decreasing in fish tissue in Town Lake, although individuals can still be found above the FDA action levels for some pollutants. Mercury levels, in particular, would result in fish consumption limits based on the new US EPA reference dose, which has not yet been adopted by the State of Texas.
- Removal of Town Lake from the fish advisory list is partially due to reduced concentrations and partially due to changes in EPA reference doses used in ban calculations.

- Additional fish tissue sampling for mercury should be conducted if Texas adopts the new US EPA reference dose for mercury. Analysis of fish tissue for organochlorine compounds and PCBs could be used to confirm or reject the declines in other pollutants.

## REFERENCES

City of Austin. 1992. "Diagnostic Study of Water Quality Conditions in Town Lake, Austin, Texas, Volume I". Water Quality Report Series. COA-ERM/WRE 1992-01. City of Austin Environmental and Conservation Services Department, Environmental Resources Management Division.

City of Austin. 1994. "Town Lake Sediment and Fish Tissue Data Analysis Series. COA-ERM/WRE 1994. City of Austin Environmental and Conservation Services Department, Environmental Resources Management Division.

City of Austin. 2002. "Update of Diagnostic Study of Conditions in Town Lake, Austin, Texas. COA-ERM/WRE 2002-01. City of Austin Watershed Protection and Development Review Department, Environmental Resources Management Division. (Not yet finished)

Environmental Protection Agency. 2001. "Water Quality Criteria: Notice of Availability of Water Quality Criterion for the Protection of Human Health: Methylmercury". Federal Register: January 8, 2001 (Volume 66, Number 5, Pages 1344-1359).

Food and Drug Administration. "Action Levels for Poisonous and Deleterious Substances in Fish and Shellfish for Human Food". Industry Activities Staff Booklet, August 2000.

Texas Department of Health, Seafood Safety Division. 1995. "Analysis of Risk from Consumption of Fish taken from Town Lake".

Texas Department of Health, Seafood Safety Division. 1997. "Fish Advisories and Bans".

Texas Department of Health under Cooperative Agreement with the Agency for Toxic Substances and Disease Registry. 1999. "Health Consultation, Town Lake, Austin, Travis County, Texas".